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EXPERIMENTAL CONTROL OF CERTAIN REGULATORY PROCESSES IN *HARENACTIS ATTENUATA*.

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In my study of form regulation in *Cerianthus*¹ it was shown that distension of the enteron with fluid was an important factor in regulation in this form. More recent work on *Harenactis attenuata* an actinian inhabiting the tide flats near San Diego, Cal.,² has confirmed my earlier conclusions and has afforded certain striking examples of the importance of distension for the persistence of parts. The results of my work on *Harenactis* will be presented elsewhere, but it seems desirable to give a brief account of certain experiments at this time since they illustrate so clearly not only the importance of distension but the possibility of experimental control of the course of regulation.

These experiments are concerned with the production of partial discs proximal to the original disc in consequence of cuts part way through the body. In my earlier experiments of this kind on *Cerianthus*³ it was found that in all cases the region directly distal to the partial disc underwent atrophy and disappeared and the partial disc gradually migrated toward the distal end of the body and finally took the place of the atrophied portion. I pointed out that the atrophy in these cases was very evidently due to insufficient distension or absence of distension in the part concerned and showed that the method of closure of the wound in such cases resulted in isolation of the enteric cavity of the atrophying region both from the exterior and from other portions of the enteron. Although the entrance of water through the wall of the body is apparently possible to a greater or less ex-

¹ Child, "Form Regulation in *Cerianthus*," I.-IX., BIOL. BULL., Vols. V.-VIII., 1903-5.

² Child, "Form Regulation of *Harenactis attenuata* in Altered Environment," BIOL. BULL., Vol. XVI., No. 1, 1908.

³ Child, "Form Regulation in *Cerianthus*, VIII., Supplementary Partial Discs and Heteromorphic Tentacles," BIOL. BULL., Vol. VIII., No. 2, 1905.

tent, the usual degree of distension cannot be maintained in this way and in the absence of the functional stimulus produced by distension atrophy occurs.

In the case of *Harenactis* the occurrence or non-occurrence of atrophy depends upon the conditions of the experiment and the result can be controlled.

The possibility of experimental control in *Harenactis* depends on the position of the mesenterial ostia in the œsophageal region.

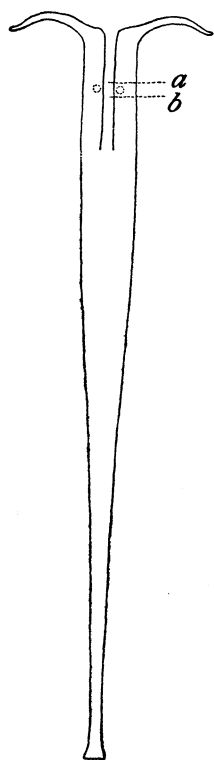


FIG. 1.

The ostia are readily seen in anæsthetized specimens opened under water. Their approximate position is indicated by the small dotted circles on each side of the œsophagus in Fig. 1. This figure represents an individual in the extended condition characteristic of the normal habitat, a vertical burrow in the sand. When the animals are kept without sand extension is never as great as in the burrow and the animal gradually becomes incapable of any considerable extension.¹ Under these conditions the ostium appears to lie much nearer the distal end than in Fig. 1. Each mesentery possesses an ostium, consequently the inter-mesenterial chambers are in direct communication with each other about the whole circumference of the œsophageal region.

I have been unable thus far to discover the ostia in *Cerianthus* or to find references to them in the literature, so far as it is accessible to me. But whether they are present or not my experiments show very clearly that distension of the region directly distal to a lateral incision in the œsophageal region does not occur. The most casual examination of specimens after healing of the wound produced by such an operation is sufficient to show that this region is either completely collapsed or only very slightly distended.

¹ Child, "Form Regulation of *Harenactis attenuata* in Altered Environment," BIOL. BULL., Vol. XVI., No. 1, 1908.

In *Harenactis*, as in *Cerianthus*, the healing of the wound made by a lateral incision in the œsophageal region and deep enough to involve the œsophagus occurs in the manner indicated in Fig. 2. The cut surfaces of the body-wall and the œsophagus unite with each other both distal and proximal to the cut so that a new lateral opening into the œsophagus is formed, its extent depending on the extent of the incision. The factors concerned in this method of closure will be discussed elsewhere: at present we are concerned merely with the fact of closure in this manner. After healing of the wound tentacles appear proximal to the opening, *i. e.*, on the distal end of the region below the opening, their number depending on the number of inter-mesenterial chambers which were cut across by the incision. So far *Harenactis* and *Cerianthus* are alike. In *Harenactis*, however, but not in *Cerianthus*, heteromorphic tentacles appear somewhat later at the proximal end of the region distal to the cut (Figs. 3 and 5). As will be shown elsewhere heteromorphic tentacles appear much more readily in *Harenactis* than in *Cerianthus* under various conditions. After these lateral incisions in the œsophageal region they always appear. If the old disc is removed at the time the lateral incision is made tentacles develop about the whole circumference of the distal end of the body. My figures represent cases in which the original disc was left intact: the final result is the same whether the old disc is removed or not.

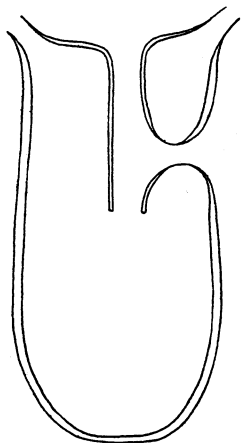


FIG. 2.

After an operation of this kind in *Harenactis* there exists then a region distal to the lateral opening in which the inter-mesenterial chambers are completely shut off from other portions of the enteric cavity in the longitudinal direction. The presence or absence of communication in the transverse direction, however, depends on the position of the incision: if this was made distal to the ostia (*a*, Fig. 1) each chamber is completely isolated from the others and from other portions of the enteron; if, on the other hand,

the incision was proximal to the level of the ostia then all the chambers distal to the incision are in communication with each other and with the enteric cavity in general. In the first case distension of other portions of the body with water has no effect upon this region, but in the second, distension of other parts is accompanied by distension of this region.

In *Harenactis*, as in *Cerianthus*, a considerable degree of distension exists when the animals are undisturbed, consequently body-wall, tentacles and mesenteries are subjected to a certain degree of mechanical tension as a characteristic feature of normal life. The following experiments show very clearly the importance of this distension as a factor in determining the persistence or atrophy of parts.

Fig. 3 is a diagrammatic longitudinal section of an animal ten days after a lateral incision just distal to the level of the ostia (α , Fig. 1). Tentacles have developed proximal and distal to the opening as usual, but the whole region distal to the opening is

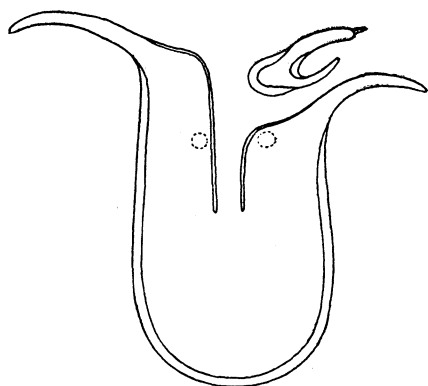


FIG. 3.

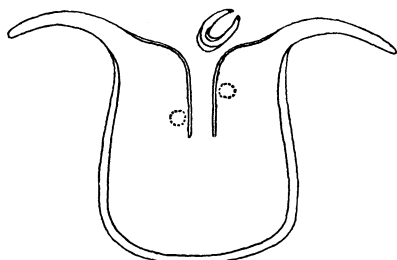


FIG. 4.

much less distended than other parts of the body. The old tentacles at the distal end of this region are undergoing atrophy, as is indicated by their length as compared with the tentacles of the other side of the body and by the degenerating region at the tip: the heteromorphic tentacles at the proximal end of this region are small and short; on the other hand, the tentacles proximal to the incision are nearly as long as the old tentacles on the other side of the body.

Observation of such cases in distended and collapsed condition establishes the fact that changes in the degree of distension of other regions do not alter the distension in the region directly distal to the incision. In all such cases this region acquires a certain degree of distension after healing of the wound, undoubtedly in consequence of the passage of water through the walls, but this distension gradually decreases as time goes on until finally collapse is complete.

The condition of such animals three to four weeks after the operation is indicated in Fig. 4. The region distal to the cut has undergone rapid atrophy and the partial disc below it has attained the same level as other parts of the old disc. The atrophied region is now completely collapsed and in an oral view of the animal forms merely a narrow strip across the disc with a mouth opening on each side of it.

A little later this strip breaks and its two ends become still further reduced and soon undergo complete resorption or in some cases drop off, leaving a normal disc.

The result is very different when the incision is made proximal to the level of the ostia, *e. g.*, at *b*, Fig. 1, or any level proximal to this within the œsophageal region. In such cases (Fig. 5) the old tentacles distal to the incision do not undergo atrophy and the heteromorphic tentacles become almost or quite as long as the others. Moreover, examination of the specimen shows at once that the whole region distal to the incision is as fully distended as other parts of the body when the animal is undisturbed, and when contraction and expulsion of water occurs this region takes part in the change, becoming distended again when other parts of the body distend. Fig. 5 shows an individual of this kind two weeks after the operation, a time when atrophy has already begun in cases of operation distal to the ostia. In my experiments a considerable number of these cases were kept for four and a half months. During this time decrease in size of the whole body occurred since the animals were not fed and in most cases both the oral and aboral tentacles of the region distal to the incision became somewhat shorter than the others, though there was no visible atrophy such as occurs in the other cases (Fig. 3). Fig. 6 shows an individual of this kind one hundred

and thirty-six days after operation. The region distal to the incision is somewhat shorter than in the early stages but it still shares in the distension of the body, the tentacles are fully functional and the tissues appear to be in perfectly healthy condition. The termination of my stay at La Jolla made further observations impossible, but there can be little doubt that this region would have remained intact and normal almost or quite as long as other

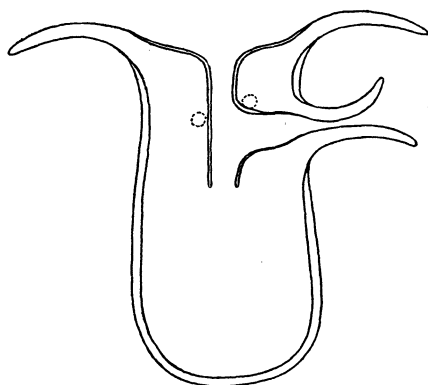


FIG. 5.

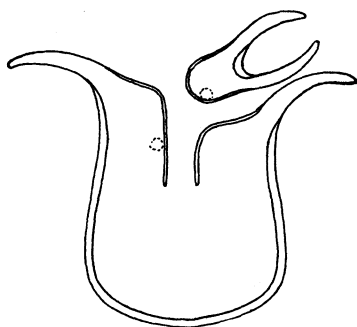


FIG. 6.

portions of the body. The fact that the tentacles of the region in question are often somewhat shorter than others is probably to be accounted for by nutritive conditions. The animals are undergoing slow starvation and apparently the material of the more proximal regions is used in greater or less degree in maintaining the more distal regions. But the region distal to the incision is only indirectly in organic connection with the proximal regions and therefore, in all probability, uses up its own material somewhat more rapidly than other portions of the body.

These two series of experiments seem to me to demonstrate that the conditions resulting from distension of the enteric cavity with fluid are necessary for the persistence of the body-wall and tentacles. When the incision is made distal to the level of the ostia the region distal to it cannot share in the distension of other parts and consequently undergoes complete atrophy in about a month. When the incision is made proximal to the level of the ostia this region shares in the distension of other parts and shows

no appreciable degree of atrophy within four and one half months. Discussion is unnecessary.

In a number of cases the lateral incision was made somewhat obliquely so that one end of it was distal to the level of the ostia, the other proximal. In these cases the part in which ostia were present became distended after healing, produced tentacles almost or quite as long as the others and persisted during four and one half months: the part from which ostia were absent became slightly distended after healing, produced short tentacles, then underwent gradual collapse and complete atrophy within a few weeks. Consequently these animals in their final condition possessed a structure arising from one end of the lateral incision and ending free, since the part which originally connected it with the other end of the incision had atrophied, and bearing tentacles on its oral and aboral surfaces. In certain respects these cases are the most interesting of all, since the two different results can be observed in a single animal.

To sum up: it is possible to determine experimentally whether persistence or complete atrophy of certain parts of the body of *Harenactis* shall occur: the factor determining the result is the distension of the enteric cavity with fluid or the absence of such distension.

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December, 1908.